A POLARIZATION ANALYSIS OF THE LIGHT EMITTED BY A STRIATED ARGON DISCHARGE

RICHARD R. COLLINS

A POLARIZATION ANALYSIS OF THE LIGHT EMITTED BY A STRIATED ARGON DISCHARGE

by

Richard R. Collins
Lieutenant, United States Navy
B.S., The St. Lawrence University, 1958

Submitted in partial fulfillment
for the degree of

MASTER OF SCIENCE IN PHYSICS

from the

U. S. NAVAL POSTGRADUATE SCHOOL
May 1966

ABSTRACT

An analysis is made of the 8115 A light emitted from the striated positive column of an Argon glow discharge to determine whether or not it is polarized. The procedure consists of separating the perpendicular and parallel components of vibration with a Wollaston prism, measuring the intensity of each component with a photomultiplier tube and comparing the signal intensities on a dual-trace oscilloscope. Within the limitations placed upon the measurements by photomultiplier noise and system frequency response, no polarization is observed. The maximum polarization that could escape detection is 3%.

The theory of polarization by electron impact is briefly discussed and related to the moving striation discharge.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

1. Introduction

The presence of moving striations, alternate bands of darkness and light travelling through the positive column of the glow discharge in an inert gas, have yet to be satisfactorily explained, despite the considerable amount of effort put into their investigation in past years. An extensive survey of this effort has been made by Cooper [1], who investigated the effect of such parameters as tube dimensions, gas pressure and discharge current on the behavior of the striations by use of rotating mirror photography, phototube detection, and Langmuir probes.

Other works in this field include those of Donahue and Dieke [3, 4], who observed different modes of striations; Robertson [10], who correlated experimental observations with theoretical ion-balance equations, and Robertson and Hakeem [11], who demonstrated the dependence of striations on metastable states.

These and many other efforts have resulted in an accumulation of data on the behavior of these striations in response to the variables of their environment, and to the growth of several theories on the mechanism of their creation. However, no substantiated theory has yet evolved. The purpose of this polarization analysis is to obtain information concerning the electric field in the striated positive column and thus contribute one segment of understanding.

The major portion of this kind of a glow discharge consists of the positive column, which extends from the Faraday dark space to the anode glow. A complete description of each part of the glow discharge has been made by Emeleus [5].

This report is concerned with argon glow discharges in a discharge tube having an inner diameter of approximately 2.5 cm

containing argon at a pressure of 5-15 Torr. For such a discharge, the total voltage across the tube is near 300v. In the positive column, the electric field is small, of the order of 3v/cm [1]. The cathode fall is 100-150v.

The D.C. electric field in the positive column on the axis of the discharge is insufficient to produce atomic excitations unless the electron travels at least 5 cm (to acquire at least 14.78 ev). The fact that the atoms are excited, and the discharge produces the atomic spectrum, is the result of thermal excitation and/or electric field perturbations.

With the proper combination of tube diameter, gas pressure and discharge current, moving striations are present in the positive column. At the front of the striation, the light intensity rises rapidly to a maximum and then decays relatively more slowly. Dachos [2] determined the ratio of rise time to decay time to be about one to four, with a rise time of 0.3 millisec and a decay time of 1.2 millisec. Also, he detected a small, but significant, difference in the times when different spectral lines began their intensity rise.

For instance, a line whose upper state was 13.02 ev above the ground state began to rise in intensity 25 microsec before a line whose upper state was 14.78 ev. This observation suggests that the electrons are being accelerated in a local region by an electric field of such magnitude that 25 microsec are required for the electron to accumulate 1.76 ev. If such local fields exist, the moving striations could be the result of moving fields. The fields could be created by either of two mechanisms. One mechanism could be electron bunching, resulting in a longitudinal wave moving through the discharge with striation velocity. The other could be a transverse electromagnetic

wave propagating through relatively stationary particles.

The next step, then, is to determine if local fields are formed by either of the above mechanisms. If the electrons are accelerated by a longitudinal electric field, they will receive an organized component of velocity parallel to the axis of the discharge tube. On the other hand, if they are accelerated by a transverse electromagnetic wave, this organized velocity would be perpendicular to the axis. If atomic radiation excited by electron impact is polarized, either of the mechanisms should produce polarization in the emitted radiation. The longitudinal field should result in the parallel component of polarization predominating, while the transverse field should do the same for the perpendicular component.

A theory has been developed by Percival and Seaton [9] expressing the polarization of dipole radiation emitted by atoms excited by a unidirectional electron beam. The polarization is expressed in terms of the probability that the complete system of target atom and colliding electron will emit a polarized photon. The calculations are based upon the Oppenheimer-Penny (O-P) theory, in which the probability of excitation to an upper quantum state and the probability of this excitation resulting in emission of a polarized photon are considered separately. In making the transition from the O-P theory to their own, Percival and Seaton made several assumptions. They assumed that there is a completely isotropic distribution of spin directions in the incident beam of the electrons and in the initial states of the atoms; that the initial level of the target atoms has zero orbital angular momentum; and that the interaction is such that total spin and total orbital angular momenta are separately conserved. They then proceeded by generalizing the Bremsstrahlung formula for

emission by an electron in a central field and determining rate coefficients as a function of direction, for the emission of photons of specified energy.

The resulting expression for the polarization (P) of emission due to transitions from upper D states is

$$P = 100 \frac{G(Q_0 + Q_1 - 2Q_2)}{h_0 Q_0 + h_1 Q_1 + h_2 Q_2}$$

In this equation, G is a parameter which depends on the dipole matrix element (transition probabilities) for transitions between the initial and final quantum states. The values of Q, one for each value of M_L, are determined by the cross sections for excitation into these upper states by electron collision. The values of h depend principally on statistical weights.

The transition probabilities have been measured for many cases, but the excitation cross sections are not reliably established. As a result, the reliability of the calculated values of polarization is limited.

Previous to this work by Percival and Seaton, Skinner and Appleyard [12] had observed such polarization. It was observed that lines belonging to the same type of spectral series experience very similar polarization. Therefore Percival and Seaton compared the experimental results of Skinner and Appleyard for Hg 7 $^1D_2 \longrightarrow 6\ ^1P_1$ with their own calculations for He 3 $^1D_2 \longrightarrow {}^1P_1$. The observed polarization rose to a maximum with decreasing electron energy and then decreased, tending toward zero at threshold. The theoretical and observed polarizations agreed quite well for the higher energies, but departed from each other at the lower energies where the theoretical

polarization continued to rise, rather than drop toward zero.

More recently, McFarland and Soltysik [8] conducted an experiment on the polarization of light emitted as a result of the excitation of helium by a unidirectional electron beam. Their results were similar to those of Skinner and Appleyard, in that the polarization dropped to zero at threshold energies. Their data indicates that for the $3\ {}^3D \rightarrow 2\ {}^3P$ transition, which is in the same type of spectral series as the argon 8115 A line, the maximum polarization, which occurred at an energy of about 25 ev, was approximately 10%. The polarization dropped off rapidly from there with decreasing electron energy, reaching zero at about 20 ev. Percival and Seaton predicted a threshold polarization of 32%.

Consequently, we are left with a choice between an unproven theory and one set of experimental results. If the theory is correct, a significant polarization (32%) can be expected if any region exists in the discharge where the electrons have at least threshold energy (14.78 ev) and are unidirectional. On the other hand, if the results of McFarland and Soltysik are correct, the polarization would be negligible around threshold energies, rising to a maximum of 10% about 6 ev above threshold.

2. Experimental Procedure

The light emitted by the argon discharge was separated into its perpendicular and parallel components of polarization by a light analyzer which included a Wollaston prism. This prism received a single light beam from a collimator and transmitted a perpendicular component beam and a parallel component beam with a divergence of about twelve degrees. These two beams were detected by separate photomultiplier (p-m) tubes (see Appendix I and Fig. 8).

The light analyzer was positioned adjacent to the argon discharge tube so that the collimator was perpendicular to the tube and aimed approximately at its center with the slit in a vertical position. Vertical adjustment for proper positioning was provided.

An aluminum container of liquid air was placed on the lid of the light tight box to cool the p-m cathodes and thus reduce their dark currents to a tolerable level. The temperature of the Wollaston prism was kept near room temperature by insulating it from the p-m tube compartment and at the same time conducting heat to it through the collimator.

The high voltage supplies of the two p-m tubes were adjusted prior to each measurement to provide outputs of equal magnitude while unpolarized light was incident upon the collimator. Unpolarized light was provided by increasing the discharge current until the striations being investigated disappeared. During this balancing procedure, a mechanical disc chopper was used to provide a pulsating signal. At the higher discharge current (0.9 amp) used during balancing, the positive column of the glow discharge still had some high-frequency low-amplitude striations (approx. one kc). However, their only effect on the balancing was that of noise, since the frequency of the chopper was much less than that of the striations, and the amplitude of the signal provided by it was at least twenty times the amplitude of the high frequency signal.

A reflection shield was placed between the 90 degree reflector and each p-m tube, with a slit large enough to accomodate the light beam from the collimator. This prevented that portion of the light beam reflected by the face of a p-m tube from reaching the other p-m tube.

The Wollaston prism was positioned so that it would split

the light beam into components with polarizations parallel and perpendicular to the axis of the discharge tube. Whenever a difference in amplitude of the two components was indicated, the prism was rotated 180 degrees so that the two channels of the system would exchange components.

The intensities of the parallel and perpendicular components of polarization were compared at two different gas pressures by observing the difference signal. The difference signal was also observed while the light was partially polarized by a glass plate inserted into the beam at an angle of 30 degrees. The above measurements were repeated with the 8115 A filter removed to obtain greater sensitivity.

3. Analysis of Data

The most significant factor limiting the accuracy of the measurements was noise. The p-m thermal noise was reduced by the cooling (Fig. 1) from approximately four mv to one mv, at the high voltage settings indicated.

If any differences in intensity greater than the noise level occurred, the sensitivity to this difference would be limited by the frequency response. The system response to a strobe light (Fig. 2) shows that the rise time of the system is no more than ten microsec/50 mv. A typical period for the striations is 1,5 millisec. Since any polarization would occur at the front of the striation, the rise time is the portion of the response which is of importance. Therefore the system would see any difference which was above the noise level, if it had a pulse width of at least ten microseconds.

Fig. 3 shows the system reaction to inserting a glass plate at an angle of 30 degrees into the light beam. The difference signal is displaced an amount indicating 3.3% polarization. The

theoretical polarization resulting from the inserted plate is 3.1%, indicating that the system would detect this level of polarization if it were present.

4. Results and Conclusions

No polarization of the light emitted from the positive column of the striated argon discharge was detected. If any polarization was present, it was less than 3%. Based on the previous results of Percival and Seaton as well as those of McFarland and Soltysik, it appears that if any organized motion of electrons is causing excitation in the positive column, this process is negligible, compared to thermal excitations. This in turn suggests that if electrons are accelerated by any local fields strong enough to provide excitation energy, these electrons are experiencing many more elastic collisions than inelastic. Consequently, a determination of the nature of any such fields by polarization analysis appears unlikely.

5. Recommendations for Further Study

As shown by Figures 4.(a) and 4.(c), the limitations on the detection sensitivity is p-m and signal noise, with the signal noise being greater. Although p-m noise could be reduced by using p-m tube holders designed for cooling by liquid air, there is little that can be done about the discharge noise. In view of this and the conclusions above, further polarization analysis by any method presently available does not appear to be promising.

6. Acknowledgements

The author wishes to thank Professor R. L. Kelly for his most helpful advice and guidance. Appreciation is also expressed to Mr. M. K. Andrews for assembling the optical system, to Mr. R. C. Moeller for maintaining the vacuum system

and providing rapid machine shop service, and to Messieurs J. W. van Gastel Jr., J. Harvey and J. Carlson for their technical assistance.

BIBLIOGRAPHY

1. Cooper, A. W. Moving striations in the inert gases. PhD Thesis, Queens University of Belfast, 1961.

2. Dachos, John A spectroscopic investigation of moving striations in an argon glow discharge. MS Thesis, U. S. Naval Postgraduate School, 1965.

3. Donahue, T. M. and Dieke, G. H. Oscillatory phenomena in direct current glow discharges. Physical Review, v. 81, January 1951: 248.

4. Donahue, T. M. and Dieke, G. H. The moving striations in argon glow discharges. The Johns Hopkins University, Tech. report no. 3; Contract N6 ONR-243, Task order IV, 1959.

5. Emeleus, K. G. The Conduction of Electricity Through Gases. John Wiley & Sons, Inc., 1951.

6. Fedorov, V. L. and Mezentsev, A. P. The polarization of radiation excited by electron impact. Optics and Spectroscopy, v. 19, no. 1, July, 1965: 5.

7. Fyodorov, V. L. Polarization of the 5770 A mercury line arising from electron impact. Optics and Spectroscopy, v. 19, no. 1, July, 1965: 79.

8. McFarland, R. H. and Soltysik, E. A. Polarization of light resulting from the excitation of helium by electrons. Physical Review, v. 127, no. 6, 15 September 1962: 2090.

9. Percival, I. C. and Seaton, M. J. The polarization of atomic line radiation excited by electron impact. Philosophical Transactions of the Royal Society of London, v. 113, no. 251, 1958: 113.

10. Robertson, H. A. Moving striations in direct current glow discharges. Physical Review, v. 105, January 1957: 368.

11. Robertson, H. S. and Hakeem, M. A. Moving striations in glow discharge plasmas. Proceedings of the Fifth International Conference on Ionization Phenomena in Gases, v. 1, 1961: 550.

12. Skinner, H. W. B. and Appleyard, E. T. S. The Polarization of light emitted by mercury when excited by electrons. Proceedings of the Royal Society (London), v. A117, 1927: 224.

APPENDIX I
DESCRIPTION OF APPARATUS

1. Vacuum System

A schematic diagram of the vacuum and gas systems is shown in Fig. 6. The vacuum system contained the following equipment:

(a) Type ED-35 Edwards Speedivac Fore Pump (5.3 c.f.m.)

(b) Veeco 2" air cooled diffusion pump (85 l.p.s. at 5×10^{-5} Torr)

(c) 2.5 liter copper trap attached to the top of the diffusion pump

(d) Ultek Model 50-121 sorption pump

Pressure measurements were made by two thermocouple gauges and an ion gauge. One thermocouple was located on the discharge tube side of the main cut-off valve and the other between the diffusion pump and fore pump. A Logatorr Model 7T ionization gauge, utilizing an RG-75 ion gauge tube, was connected between the cold trap and main cut off valve. The minimum pressure was 1×10^{-7} Torr.

2. Discharge Tube and Gas System

The discharge tube was made of pyrex precision glass tubing with an inner diameter of 1.01 inches. The electrodes consisted of a tungsten filament surrounded by a nickel anode so that each tube had two filaments and two anodes.

Prior to its being connected to the vacuum system described above, the discharge tube was connected to a portable vacuum system and degassed. The degassing process consisted of baking the tube for several hours using heating tapes; running a current of six amperes through each filament; heating the cylindrical anodes with an induction heater. This process was repeated when the discharge tube was first placed on the permanent vacuum system and whenever the discharge indicated

that degassing was required. Following the degassing, the tube was filled with argon and operated. If the striations were noisy or the discharge looked whitish, the tube was pumped out and refilled. This process of filling and operating was repeated until a pure discharge was obtained.

The source of argon gas was a one-liter pyrex flask of Linde high-purity argon. The gas pressure was measured by a manometer containing silicone DC 704 pump fluid (lcm oil = 0.782 Torr).

When the discharge tube was filled with argon, it was then isolated from the vacuum system by an Alpert ultra-high vacuum valve (type VAU-25).

3. Power Supplies

The direct current argon discharge was maintained by the following equipment:

(a) The discharge tube voltage was supplied by a Kepco Labs. Model 770B power supply (0-600v DC). The tube current was measured by an ammeter incorporated into the power supply (0-3a).

(b) The auxiliary voltage at the anode end of the discharge tube was supplied by a Kepco Labs. Model 520R-B power supply (0-600v, 0-300ma DC).

(c) The cathode was heated by a Kepco Labs. Model KM 236-15A power supply (0-50v, 0-15a DC).

4. Polarization Analyzer and Measuring Instruments

A schematic of the physical arrangement is shown in Figs. 7 & 8. The light entered a collimator 9.7 cm long, with outer slit 0.794 mm wide and inner slit 0.352 mm wide. This provided a field of view less than two mm wide in the discharge tube. While the two photomultiplier outputs were being balanced, a

slotted-disk mechanical chopper was placed in front of the collimator.

Behind the collimator was a Wollaston prism, in a rotatable holder, which could be rotated by a knob external to the light tight box.

Next in the optical circuit was an interference filter (8105 ± 85 A). This filter also served to prevent convection currents from the cold portion of the light tight box.

The two light beams, after passing through the filter, were reflected from an aluminum-coated 90-degree prism, which reflected the two beams to two facing p-m tubes.

The two RCA 7102 photomultiplier tubes were held in Quanta photomultiplier packages, Model 4002. A slotted shield was placed between the 90 degree prism and each p-m tube. The high voltage supply of each tube was provided by a Harrison 6515A Power Supply (0-1600 v, 0-5 ma). The voltage applied to the p-m tubes was between 750 and 1000 v.

The signal outputs of the photomultipliers were sent to a Tektronix type 547 dual-trace oscilloscope with a type 1A1 dual-trace DC preamplifier having a maximum sensitivity of 0.005 v/cm and a capability of displaying the difference between two signals.

The optical system and photomultipliers were contained in an aluminum light tight box with removable lid. The box, except for the portion of the lid above the p-m tubes, was insulated by fiberglass. A fiberglass and cardboard partition separated the p-m tubes from the collimator, Wollaston prism and interference filter, except for an opening large enough to permit passage of the light beams. The filter was placed against this opening to prevent convection.

A small metal container was placed on top of the lid, above the p-m tubes. It contained liquid air for cooling the phototube cathodes. A heating tape was placed around the external portion of the collimator. The collimator served as a heat conductor to keep the Wollaston prism near room temperature.

At times, when the behavior of the striations was questionable, they were visually observed with a rotating mirror, in addition to the oscilloscope presentation.

APPENDIX II

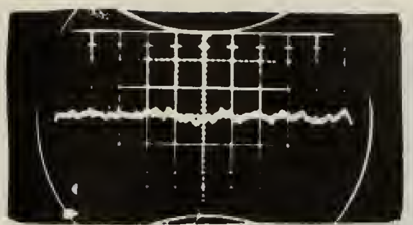
MISCELLANEOUS ITEMS

1. Use of Sorption Pump

It would be desirable to have a vacuum system that would prevent impurities from accumulating in the discharge tube and thus permit longer periods of operation without changing the gas. Toward this end, an attempt was made to find some operating temperature at which an Ultek Model 50-121 sorption pump would pump impurities without pumping argon. This was considered a possibility since some sorption pumps have been specifically designed to pump inert gases as well as others, whereas no such performance was specified for this pump. Although trials at several temperatures revealed that this pump would not discriminate against argon, and thus could not be used to remove impurities, it did prove to be very efficient for argon, pumping the discharge tube and vacuum system from 20 microns down to four microns in four minutes.

2. Reflection of Polarized Light

Part of the procedure of checking the sensitivity of the light analysis apparatus consisted of rotating the Wollaston prism, thus letting the two p-m tubes exchange components of polarization. This process revealed that the perpendicular component always reflected from the 90 degree aluminum coated prism better than the parallel component. Intensity measurements indicated that the reflecting power of the perpendicular component was 1.2 times that of the parallel component.

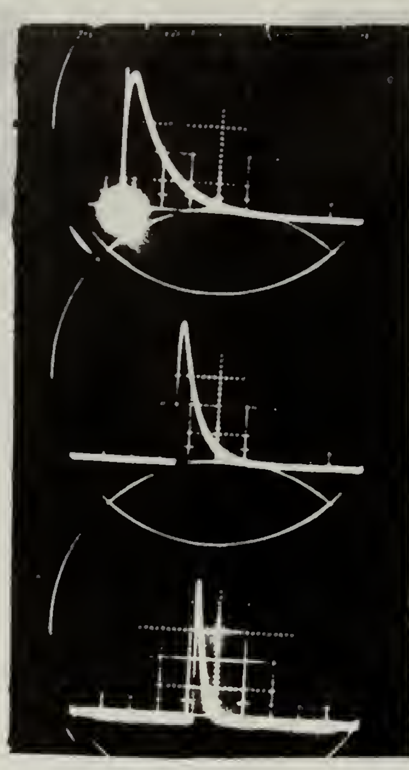


p-m at room temperature

p-m cooled

Noise level of difference signal, with no incident light. High voltage: Tube A 750 v, Tube B 800 v. Oscilloscope scale: 5 mv/cm and 0.5 millisec/cm. (one cm squares)

Fig. 1 Oscilloscope Presentation of p-m Noise Level



(a)

(b)

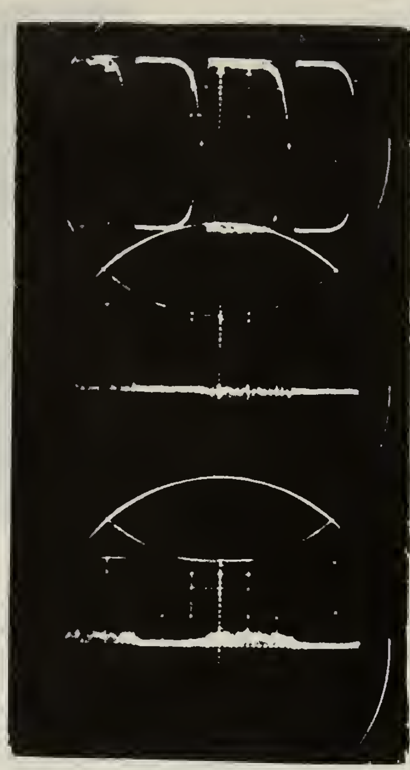
(c)

(a) Signal A 10 mv/cm; 0.1 millisec/cm.

(b) Signal A 10 mv/cm; 0.2 millisec/cm.

(c) Signal A 10 mv/cm; 0.5 millisec/cm.

Fig. 2 System Response to Strobe Light



(a)

(b)

(c)

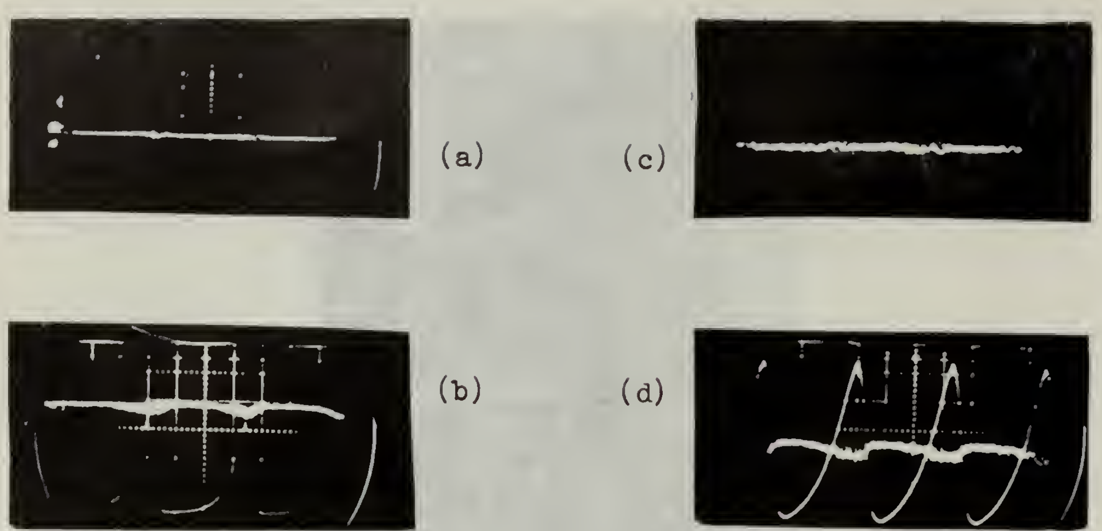
(a) Signal A inverted (zero intensity at top) and signal B upright (zero intensity at bottom). Sharper horizontal traces indicate zero intensity.

(b) Difference signal with sensitivity balanced.

(c) Difference signal with light beam 3.1 per cent polarized by a glass plate inserted at 30 degrees, after balancing sensitivity.

All pictures taken with argon pressure 8.5 Torr; Discharge current 0.9a (only high frequency striations); Mechanical chopper inserted; Oscilloscope scales: 5 mv/cm and 0.5 millisec/cm.

Fig. 3 Oscilloscope Presentation of Balancing Procedure



(a) (c)

(b) (d)

(a) Difference signal obtained with striations present. Discharge current 0.21a; Pressure 4.1 Torr.

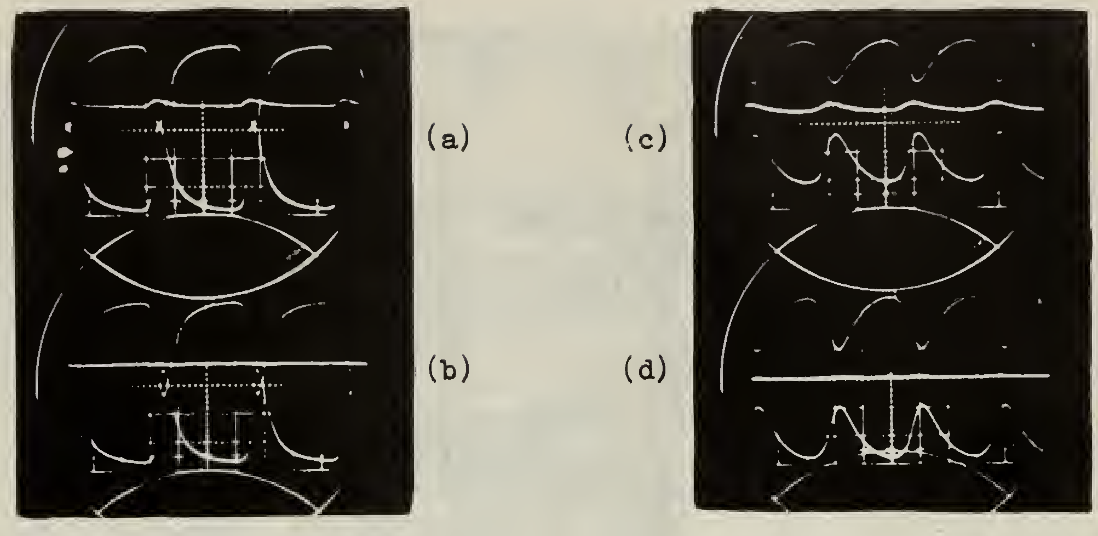
(b) Difference signal obtained with all conditions as in (a) except beam polarized 3.1 per cent by glass plate. Signal B also displayed for reference.

(c) Difference signal obtained with striations present. Discharge current 0.32a; Pressure 7.35 Torr.

(d) Difference signal obtained with all conditions as in (c) except beam polarized 3.1 per cent by glass plate. Signal B also present for reference.

Oscilloscope scales: 5 mv/cm; 0.5 millisec/cm.

Fig. 4 Difference Signal obtained from striations with 8115 A° filter inserted.



(a) Difference signal obtained with striations present and beam polarized 3.1 per cent by glass plate. Discharge current 0.22a; Pressure 4.4 Torr; Signals A and B superimposed.

(b) Difference signal obtained with all conditions as in (a) except glass plate polarizer removed.

(c) Difference signal obtained with striations present and beam polarized 3.1 per cent by glass plate. Discharge current 0.18a; Pressure 13.1 Torr. Signals A and B superimposed.

(d) Difference signal obtained with all conditions as in (c) except glass plate polarizer removed.

Oscilloscope scales: 5 mv/cm; 0.5 millisec/cm.

Fig. 5 Difference signal obtained from striations without filter

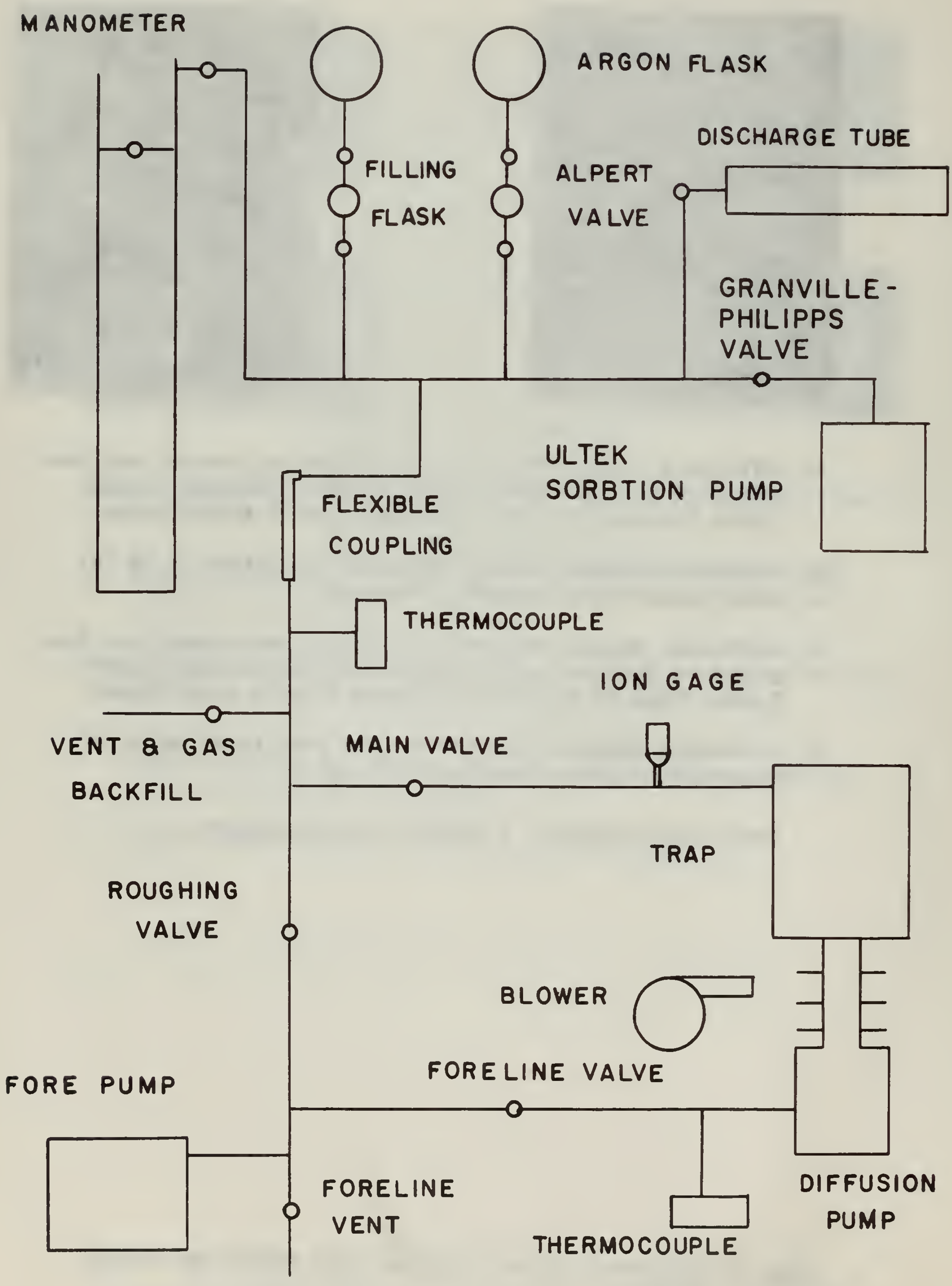
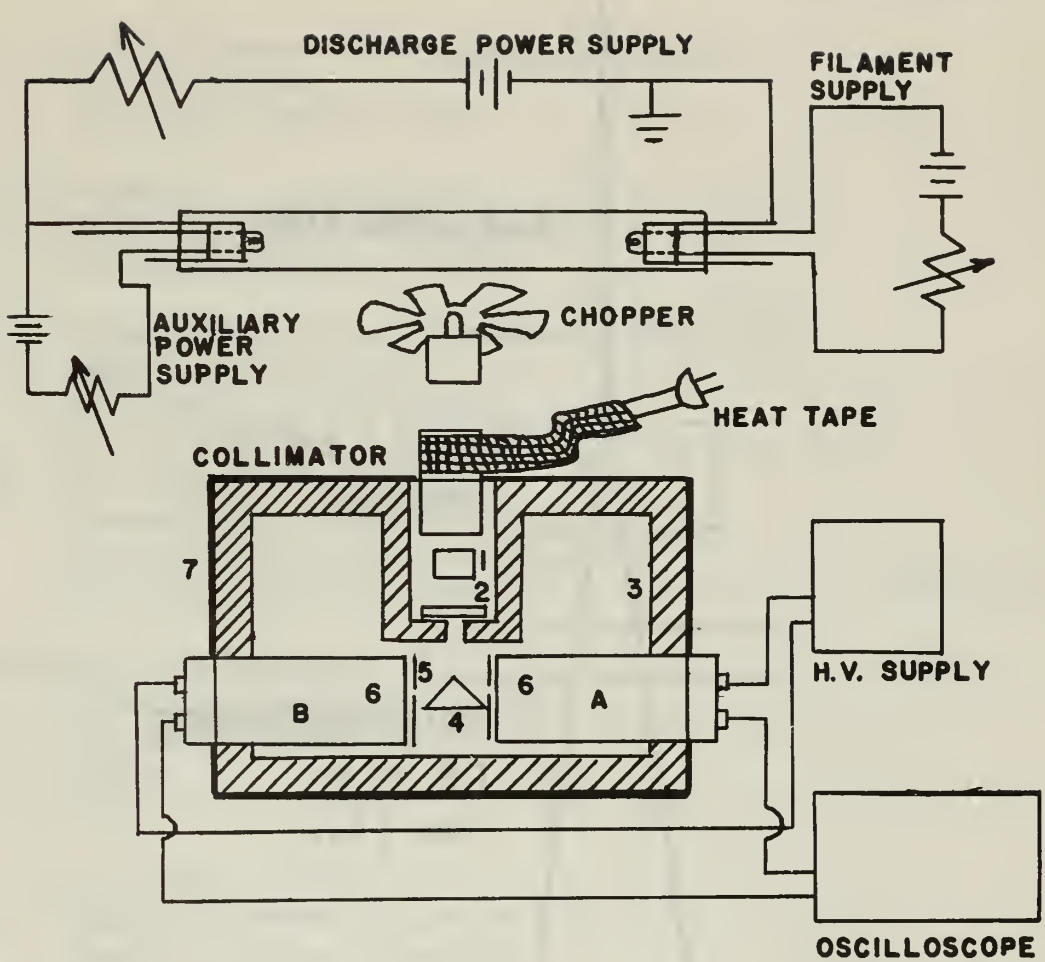


FIGURE 6 Schematic Diagram of Vacuum System and Filling System



1. WOLLASTON PRISM
2. INTERFERENCE FILTER (8105 ± 85 A)
3. FIBERGLASS INSULATION
4. 90 DEGREE ALUMINUM-COATED PRISM
5. REFLECTION SHIELDS
6. PHOTO TUBES (RCA 7102)
7. ALUMINUM LIGHT TIGHT BOX

Fig. 7 Schematic Diagram of Power Supplies, Polarization Analyzer, and Measuring Instruments

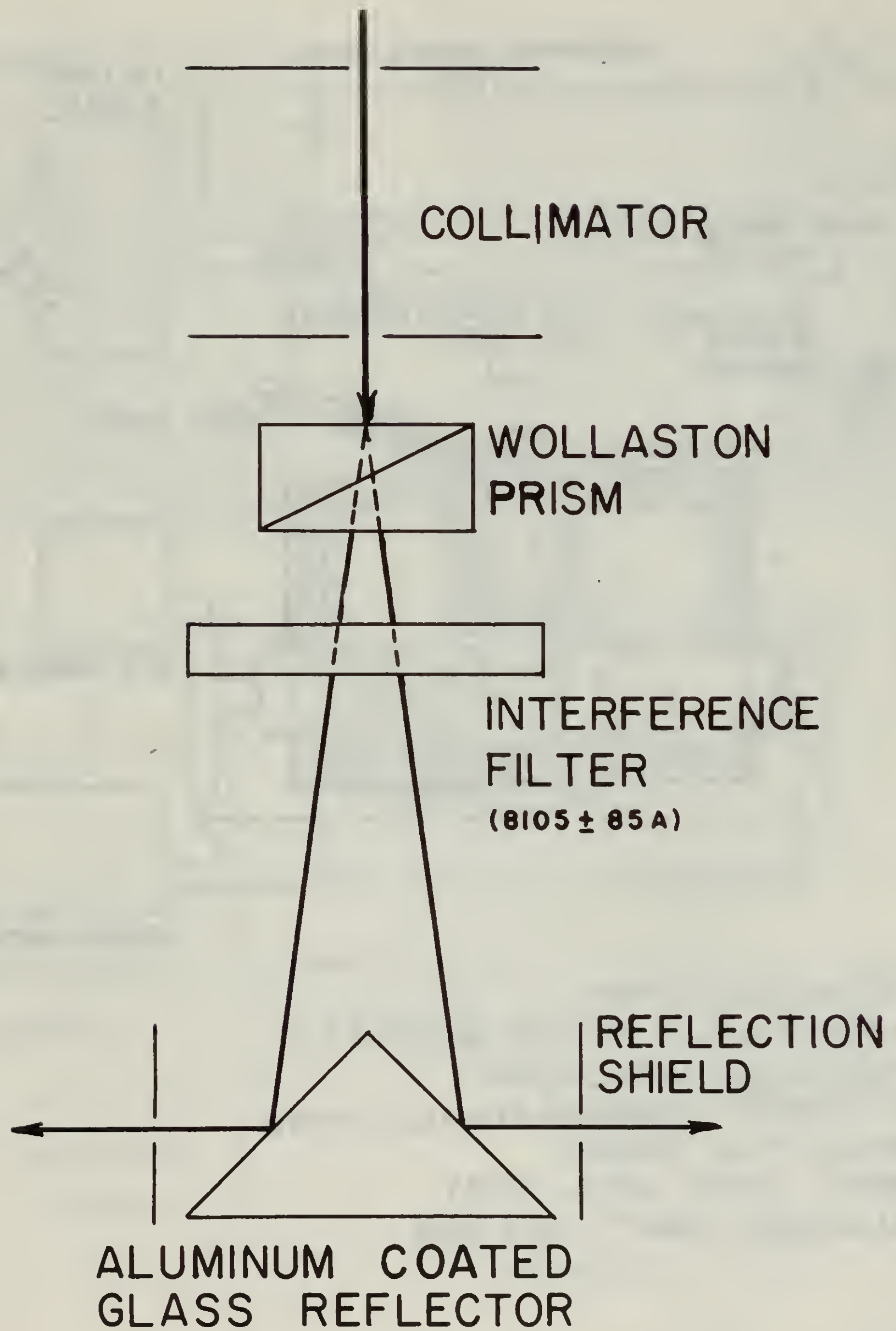


Fig. 8 Schematic Diagram of Optical System

INITIAL DISTRIBUTION LIST

		No. Copies
1.	Defense Documentation Center Cameron Station Alexandria, Virginia 22314	20
2.	Library U. S. Naval Postgraduate School Monterey, California 93940	2
3.	Chief, Bureau of Naval Weapons Department of the Navy Washington, D. C. 20360	1
4.	Prof. Raymond Kelly Department of Physics U. S. Naval Postgraduate School Monterey, California 93940	5
5.	Dr. Jerry Weinberg Hawaii Institute of Geophysics Haleakala Observatory Box 48 Kula, Hawaii 96790	1
6.	Dr. Donald Peckham Chairman, Physics Department The St. Lawrence University Canton, New York	1
7.	Lt. Richard Collins Box 1022 U. S. Naval Postgraduate School Monterey, California 93940	1

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*
U. S. Naval Postgraduate School
Monterey, California 93940

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE

A Polarization Analysis of the Light Emitted by a Striated Argon Discharge

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*
Partial fulfillment for Masters' Thesis in Physics, May 1966

5. AUTHOR(S) *(Last name, first name, initial)*

Collins, Richard R. Lieutenant U. S. Navy

6. REPORT DATE	**7a. TOTAL NO. OF PAGES**	**7b. NO. OF REFS**
May 1966	31	12

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. AVAILABILITY/LIMITATION NOTICES

This document has been approved for public release and sale; its distribution is unlimited.

[redacted].

GBL
11/69

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY

Bureau of Naval Weapons

13. ABSTRACT

An analysis is made of the 8115 A light emitted from the striated positive column of an Argon glow discharge to determine whether or not it is polarized. The procedure consists of separating the perpendicular and parallel components of vibration with a Wollaston prism, measuring the intensity of each component with a photomultiplier tube and comparing the signal intensities on a dual-trace oscilloscope. Within the limitations placed upon the measurements by photomultiplier noise and system frequency response, no polarization is observed. The maximum polarization that could escape detection is 3%.

The theory of polarization by electron impact is briefly discussed and related to the moving striation discharge.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Polarization Striations Argon Glow discharge						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through
________________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through
________________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through
________________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.